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URBAN CHANGES DETECTION IN NASR CITY AND SURROUNDINGS, CAIRO , EGYPT BY USING GIS - RS TECHNIQUES

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ABSTRACT

This paper describes the application of GIS - RS techniques to detect urban growth of Nasr city and surroundings (Cairo , Egypt) from 1945 to 1993 . For this work , TM multi-spectral data (30 m resolution) from 1993, KVR-1000 image (5m resolution) from 1991 , and SPOT image (20 m resolution) from 1986 were used ; this is in addition to topographic maps with scale of 1:25,000 from 1945 and 1991.

Multi-source data is used to highlight and map urban changes in Nasr city and surroundings as an area of active urban development in Cairo city . The results can be used by local government authorities to understand development trends and for future planning .

A GIS model was designed to handle the designed data base . This prototype GIS integrates remote sensing data with other data, mostly from maps . The attribute

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data were obtained from base maps and satellite data .
High resolution satellite images , and base maps with scale 1:25,000 offered enough
details to allow identification of all features of level 2 and level 3 classification .
Classification until level4 an 5 for some categories specially residential area can be realized .
In this paper, urban change detection through the year 1945 to 1993 was highlighted . Also, a classification scheme was designed to identify land use categories in the study area in 1993 where the area for all features are presented .

1. INTRODUCTION

For planning purposes it is essential that information concerning a variety of aspects about land , particularly in towns and cities, is collected and analyzed in order to understand their past , present and future landuse patterns . In urban plaaning and human settlement analysis, information on present landuse and its day-to- day changes is a basic requirement . It provides an understanding of a complex system . This facilitates continuous reviewing of planning policies and strategies . The inventory of urban changes is required not only to have an up-to-date picture of existing landuse, but also to help record the recent improvements, as well as monitor the changes, which are constantly occuring in the different parts of the city [1] .
At present, it is found that aerial remote sensing techniques and data products are quite efficient tools in getting accurate landuse information fast and with greater cost efficiency . This technique is, thus a mean to simplify and minimize the labour of the conventional ground survey method. In order to explore this technique, a study of urban change detection has been carried out, together with limited field work in Cairo city (Nasr city, Heliopolis area and surroundings) [2].

Remote sensing (RS) system is one of the sources for input to geographic information system (GIS) . Its capability to cover large areas and its repeatability
characteristics have brought us to deal with the effective and efficient use of the data [3] .

The main objective of this study is to detect urban growth and to analyze the trend of historical perspective of urban developments for subset of Cairo city using historical maps and satellite images acquired at different dates by using RS-GIS techniques . A (GIS) is any manual or computer based set of procedures used to store and manipulate geographically referenced data . GIS are used by many
different disciplines such as engineering urban planning , and mapping sciences , each of which may be conducting a unique set of applications [4] .

A city encompasses different types of business , health centers , schools , public utilities , traffic and population . These features can be interpreted from space products and supported by GIS information to serve city requirements . Invisible attributes of features such as street names , land use classes and other heuristic information can be acquired from sources other than space products and input to the GIS data base . Accordingly, new information, different analyses, and critical decision can be obtained or supported by integrating GIS information and proper space products [4] . Moreover, integrating remotely sensed data, such as aerial photographs and space products images , with GIS leads to cost-effective tools for monitoring and managing earth resources .

A GIS model was designed to serve diverse users, furthermore, it would be capable of continuously being updated as new data became available . Due to the great amount of information that GIS may use , it is not surprising that a GIS relies heavily on high-speed digital computers (such as SUN 20 Workstation) , a comperhensive and powerful program or software package (such as ERDAS IMAGINE) , and a variety of peripheral input-output devices (such as digitizer, Printers, etc) .

2. OBJECTIVE

The objective of this paper is to design a GIS model which integrates satellite data with other data where the attribute data were obtained from satellite data and base maps . This model is used for inventoring urban land-use information and urban changes for a subset of Cairo city (Nasr city , Heliopolis areas and surroundings) from 1945 to 1993 . The extracted land - use information are used for the design of a classification scheme . Also, it is used to identify the urban area changes during the same period .

3. STUDY AREA

The selected study area represents a subset of Cairo city which includes Nasr city , Heliopolis area and surroundings . This area represents most newly developed urban regions in Cairo city . Fig.1 represents the study area .
The map coordinates for the study area are :
Upper Lift X- coordinate (ULx) = 331003.00 ;
Upper Lift Y- coordinate (ULy) = 3336490.00 ;
Lower Right X-coordinate (LRx) = 348813.00 ; and ,
Lower Right Y- coordinate (LRy) = 3315750.00

4. AVAILABLE DATA

The available data sources were used for different purposes according to their acquisition data , scale, and resolution as follows :

1) A map dated 1945 at 1:25,000 scale was studied in order to understand the general physical and topographical characteristics of the area . It is used to depict the status of the urban areas at that early stage .

2) SPOT imagery (20 m resolution) acquired in 1986. This imagery is used to detect the changes happened between 1945 and 1986 .

3) KVR-1000 imagery (5 m resolution) acquired in 1991 was investigated to give better details about different environments in the study area. Also, it is used for detecting the changes happened between 1986 ban 1991.

5) A map dated 1991 at 1:25,000 scale was studied in order to understand the general physical and topographical characteristics of the area and to assign the functionality and attributes for the extracted features .

5) TM imagery (30 m resolution) acquired in 1993 was used to detect the changes occured between 1991 and 1993.

6) A map dated 1991 at scale 1:10,000 was studied to give more details about the urban and built up area classes .

5. METHODOLOGY

Satellite imagery has been widely employed in land cover change studies in a variety of environments . The main intent of satellite data is to provide information about the physical attributes of the earth's surface without direct contact .

For achieving the objective of this work , diverse data should be available . The available data for this study compromises satallite images and georeferenced maps .

The georeferenced maps are used for rectification of the available satellite images [5] . Also, these maps are used in built-up area for urban change detection study.

The rectified images have been classified using classification techniques to identify the different categories in the images .

The extracted information are archieved in a computer- compatible digital format as a geographically referenced layers or planes called data base . These information has been moved into the designed GIS and integrated with other available information . The designed GIS model can serve many users [4 ,5] . Also it can be used for historical recording [6], change detection , and data updating and inventoring of land use classes . The procedures used for achieving this work are presented briefly in Fig. 2 .

6. THE DESIGNED GIS MODEL

A Geographic Information System (GIS) is a computerized data base management system for capture, storage, retrieval, analysis , and display of spatial data . GIS consists of four major modules : data input , data management , data manipulation and data output modules as shown in Fig. 3 [7] .
Georeferenced maps and remotely sensed data are used to provide some descriptive attributes to the system such as residential area classes, inistitutional area classes , etc. It should be stated that the relatively low resolution data, such as TM and SPOT images, are used for global interpretation purposes . Higher resolution data, such as large-scale aerial photographs, KVR-1000 (5m resolution) image and maps are used for detailed information and digitization purposes [8] .
The designed GIS model contains different sets of information in the data bank. These sets include main categories and their possible level of classification .
Many interpretive attributes could be acquired from the available data . Data acquisition and integration, GIS data preparation and classification for the designed GIS model are highlighted in section 6.1 and 6.2 respectively .

6.1. Data Acquisition and Integration

Integration of data from remote sensing and georeferenced maps within a GIS necessitated eliminating data inconsistencies . The georeferenced maps had Universal Transverse Mercator (UTM) georeferencing . The satellite images (TM , SPOT and KVR-1000) were registered and transformed to the georeferenced maps to ensure the same scale, projection , and georeferencing coordinates . This permitted the integration of the data through overlays of georeferenced maps onto the satellite images . This allowed the determination of regional land cover changes .
For the present study the GIS database was created for multi-date (1945, 1986, 1991 and 1993) data [5] .

6. 2. Preparing the GIS Data

Since this study deals with the development of a GIS model , two stages were carried out . The first stage is the acquiring of large scale data that can be classified into six main categories . Also these main categories were classified into sub classes according to the possible levels of classification .The extracted classes are : residential area classes, institutional (universities, hospitals, cemetries, military facilities, hotels, service facility and governmental facility) , recreational (parks, stadium, clubs, horce race, sport halls, exhebit) , transportation (airports) , industerial area , and open land and others .
The second stage is the acquiring attribute data , in which careful attention was given to the design of tabular format that would be linked to the system . The required information was defined in an early stage to assest and guide the interpretation process . Attributes were extracted from the available maps and satellite images .

Some image features cannot be obtained from maps and satellite images, where it may be difficult to distinguish between residential, commercial, and other buildings. The attributes were acquired from different sources including field visit, municipalities, maps, reports and others.

7 . OPERATING RESULTS OF THE GIS MODEL

The GIS has a powerful multi-purpose database that can serve many urban applications . It was intended to use the designed GIS model to show the historical growth in the urban and built up area for the subset of Cairo city . Also it is used to design land use/cover classification scheme and calculate the area for all possible levels of classification .
The land use/cover classification scheme will be discussed in section 7.1. The result of the historical growth in the urban and built up area from 1945 to 1993 is discussed in section 7.2 .

7.1. Land Use / Cover Classification Scheme

Using the available data for the study area , the urban and built up area can be classified into six categories according to the proposed classification scheme [9,10] as shown in Table 1. , where the area of the main classes and sub-classes are presented . The land - use categories shown in Table . are : residential , institutional , recreatioal, transportation, open land and others, and , industerial. This classification scheme was modified slightly from USGS.to accommodate the source materials . This scheme is flexible hierarchical system for use at multiple levels, depending on the level of detail and scale required by the application and supported by source materials . In this scheme main classes were collected and interpretation was carried out to level VI .

The map illustrates the classified six categories is shown in Fig. 4 . The area of these categories are illustrated in Fig. 5 .

7.2 . Historical Change Detection

To assess the environmental changes within the study area comparison was made between the land use map of 1945 (compiled from georeferenced map) , land-use map of 1986 (compiled from SPOT data) , land-use map of 1991 (compiled from KVR-1000 data and 1991 map with scale 1:25,000) and land-use map of 1993 (compiled from TM data) . The focus is made on the changes of the urban areas .

The maps which illustrate the historical change in the urban and built up area is shown in Fig .6 [11] . The area of the urban and built up area growth through 1945 to 1993 are plotted in Fig . 7 [5] .

The urban and built up area at 1945 was 36% of the total area at 1993. The growth in the urban and built up area from 1945 to 1986 was 56% , while it represented 7 % from 1986 to 1991 and 1 % from 1991 to 1993 .

8. CONCLUSION

Assessment and monitoring of urban areas for development requires high resolution tools to meet the needs of urban managers and decision makers . Available high resolution satellite data , such as Russian (KVR-1000) , Landsat (TM) and SPOT (HVR-2) could provide adequate information that meet these needs .

Integration of remote sensing data with topographic maps data proved to be useful for monitoring land use/cover classification up to the fifth level in some categories and generating data base of urban and built up area which was utilized by the designed geographic information system (GIS) .

GIS and remote sensing techniques are very useful and fast method to monitor and to assess urban growth urgently required by any urban planner because they can easily update any information relating to the physical growth . A GIS can help to improve the management and use of this information at all levels of an organization

The overall conclusion to be drawn from this study is that our GIS model is technically highly reliable . Most of the interpretation done , using satellite images were confirmed by georeferenced maps and field verification .

The analysis shows :

- The major axis of development appears to be oriented towards the east and the south . Heliopolis and Nasr city are important and fast growing zones .
- The new Cairo belt-way (Ring Road) has an evident impact on the development in the area .
- Prediction of the future growth can be made (around the Ring road) .
- The development in the urban and built up area is 56 % from 1945 to 1986 , 7% from 1986 to 1991 and 1% from 1991 to 1993 .
- The environment of Cairo city area showed enormous changes during the period 1945 to 1986 .

9. REFERENCES

[1] Abdel-Kader, A.F. , Onsi, H.M., El-Laithy, B.M and Abdel-Hady , M.A., "Monitoring Urban and Land use Trends in the Greater Cairo Metropolitan Area using Landsat Data ", XVII ISPRS Congress, Washington, DC USA, August 1992

[2] A.P.Subudhi and S.P. Nirokhekar, " Urban Land Change Detection Study With the Application of Aerial Remote Sensing Techniques and Data Products ."

Airphoto Interpretation for urban planning and management , case study India oct. 1987 .

[3] Bamdang Sulistyo, " Urban Growth Detection of Bengkulu Municipality by using GIS-RS Techniques , " Conference Canada 1994 .

[4] Abdullah M. Al - garni, " Urban photogrammetric data base for multi-purpose cadastral- based information systems : the Riyadh city case," ISPRS Journal of photogrammetry & Remote Sensing 51 (1996) 28-38 .

[5] M. Ali Gomaa, Ph.D program , Al Azhar University , Faculty of Engineering , Department of systems and computers .

[6] Janet S. Crawford-Tilly, William Acevedo, Timothy Foresman and Walter Prince , " Developing a Temporal Database of Urban Development for the Baltimore/Washington Region {1} " , Jan. 1997 .

[7] Thomas Eugene Avery and Graydon Linnis Berlin , " Fundamentas of Remote Sensing and Airphoto Interpretation ", New York , 1992 .

[8] M.Ali Gomaa , Fawzy El Tohamy , Adel Farid Abdel- Kader & M.Abd El Haliem , " Merging of Remote Sensing Satellite Images," the 7th International Conf. on Aerospace Sciences & Aviation Technology, Cairo , Egypt , 13-15 May 1997 .

[9] M. Lenco, Cour and F. Tourneux " Remote sensing from spac at 1:25,000 scale to study and watch the urban ecosystems in the built-up areas above 100,000 inhab" , 25th International Symposium , Remote Sensing and Global Envionmental Change , Graz, Austria , 4-8 April 1993.

[10] W.Zsilincsar and W. Sulzer , " The application of remote sensing in local planning illustrated by the Alpine town of Schladming / Austria " , 25th International Symposium , Remote Sensing and Global Envionmental Change , Graz, Austria , 4-8 April 1993.

[11] Adel Farid Abdel-Kader , Islam Hamza Abou El-Magd , Mohamed Ali Gomaa , and Mohamed A. Hassan Aly, " Integrating Remote Sensing and GIS in Support of Decision Making : Case Studies ", Regional Workshop on the Use of Environmental Information Systems for Decision Making , Kuwait, 1-3 December, 1997 .

Table 1. The proposed land-use classification scheme

	Area [m^2]
1- Urban and Built up Area	**1.27 E+08**
11 Residential Area	**8.48 E+07**
111 Continuous urban .	2.93 E+07
1111 very dense.	6.91 E+06
1112 high dense.	2.06 E+07
1113 mid dense	1.78 E+06
112 Discontinuous urban fabric .	5.55 E+07
1121 mid dense built up cover .	2.83 E+07
11211 linear housing with gardens	1.15 E+06
11212 linear housing in streets .	2.78 E+07
1122 collective housing .	6.15 E+06
11221 big blocks and towers (high)	1.04 E+06
11222 medium blocks and towers	1.32 E+05
11223 small blocks .	4.98 E+06
1123 detached housing .	2.11 E+07
11231 low dense .	4.55 E+06
11232 mid dense .	1.17 E+07
11233 scattered housing .	4.07 E+06
12 Institutional	**1.97 E+07**
121 Universities .	2.67 E+06
122 Hospital .	1.56 E+06
123 Cemetries .	6.22 E+06
124 Military facilities .	7.75 E+06
125 Hotels .	7.45 E+04

126 Service facility .	8.30 E+05
127 Governmental facility .	5.73 E+05
13 Recreational .	**6.76 E+06**
131 Parks.	2.12 E+06
1311 gardens	4.61 E+05
1312 parks between houses.	6.71 E+05
1313 governmental .	9.84 E+05
132 Stadium .	1.42 E+05
133 Clubs .	1.53 E+06
134 Horse race .	1.05 E+06
135 Sports halls .	1.49 E+06
136 exhebit .	4.77 E+05
14 Transportation .	**1.04 E+07**
141 Airports .	1.04 E+07
1411 military .	1.90 E+06
1412 civilian .	8.53 E+06
15 Open land and others .	**3.37 E+06**
151 land being developed .	2.45 E+06
152 Undeveloped land .	7.75 E+05
153 Electric station .	1.44 E+05
16 Industrial .	**2.17 E+06**
161 Heavy industerial .	1.08 E+06
162 Light industerial .	1.09 E+06

Fig.1. Study area (TM image)

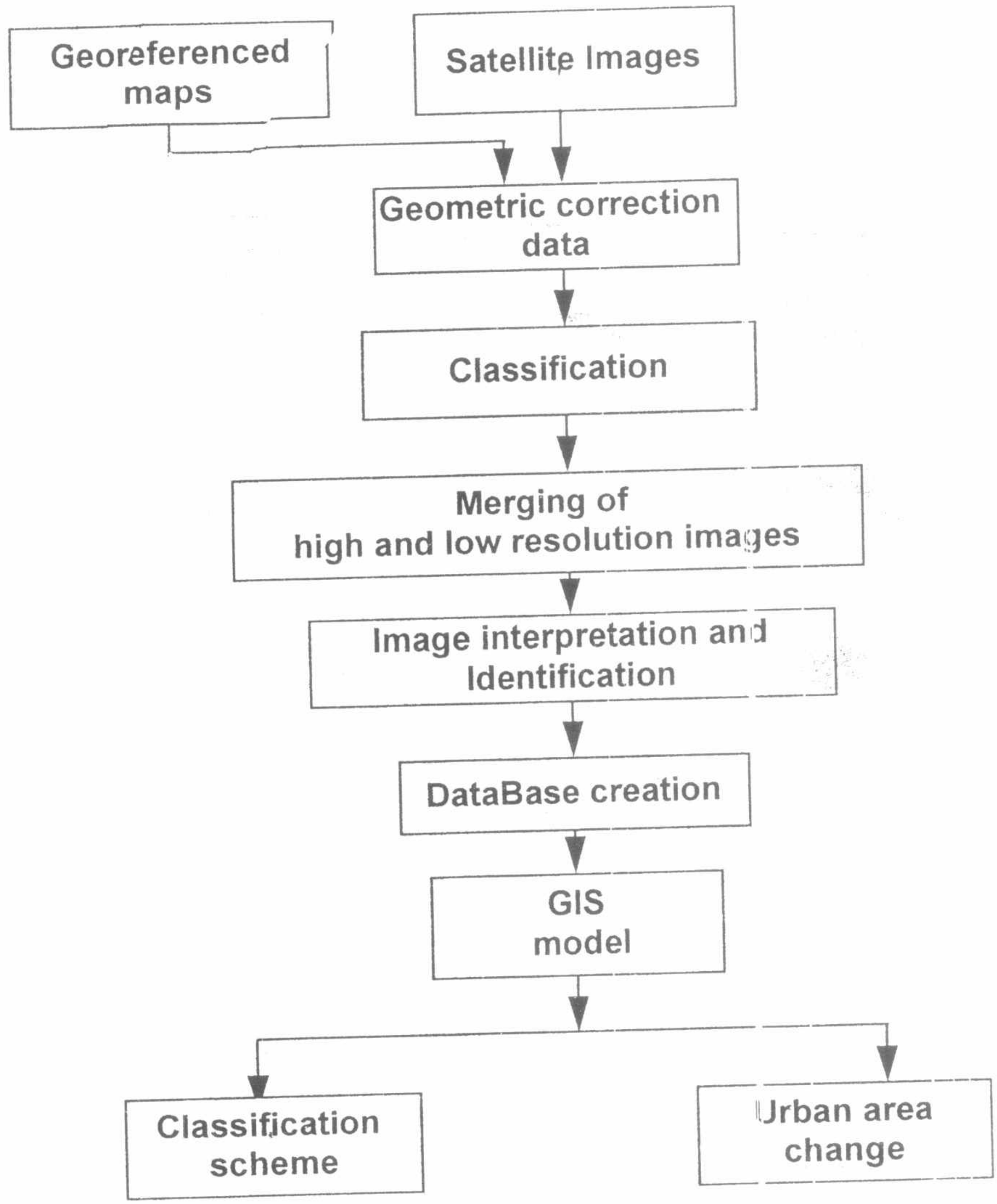


Fig.2. Methedology procedures

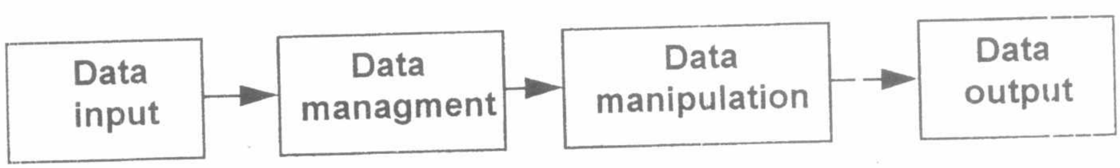


Fig.3. GIS configuration

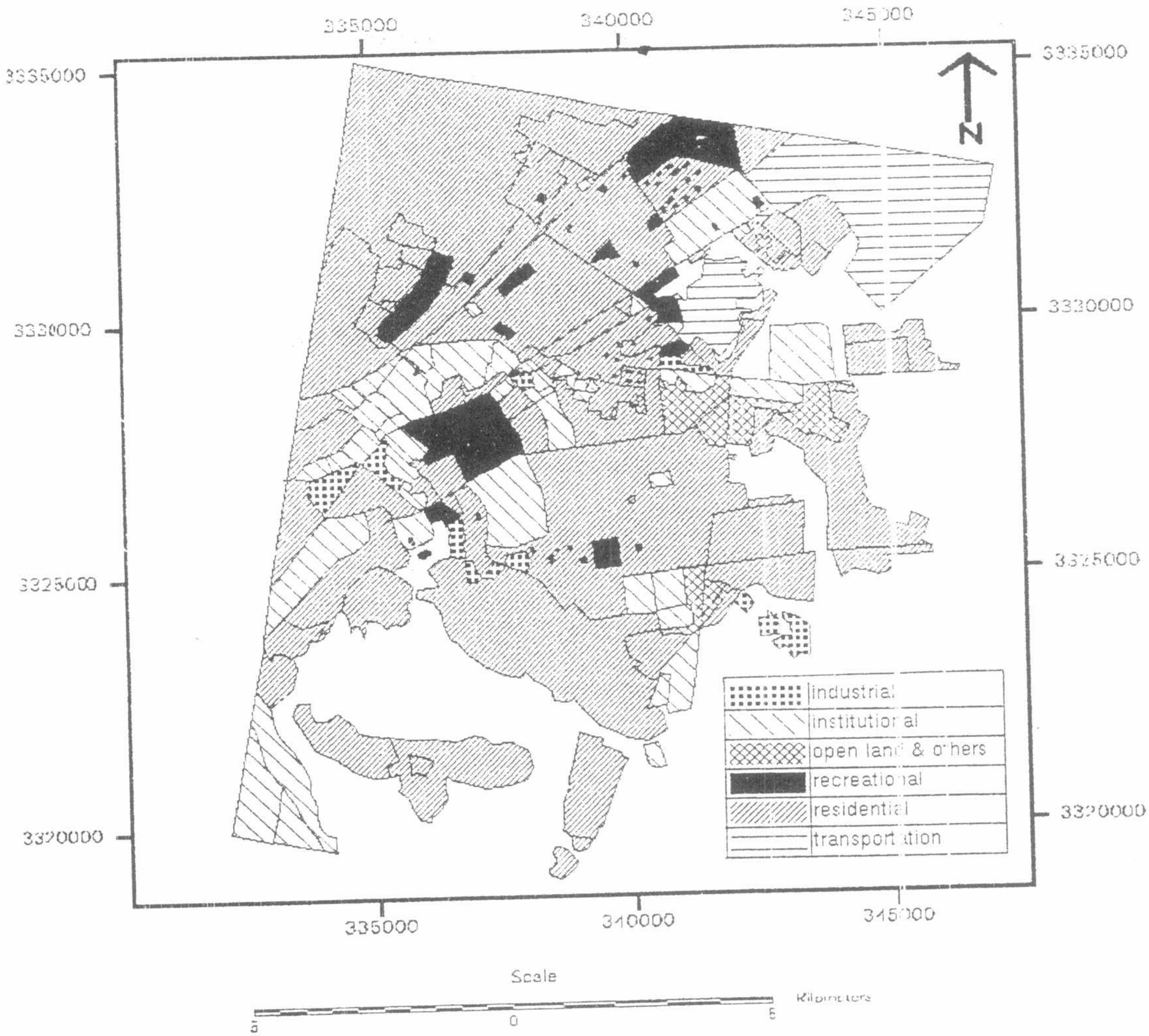
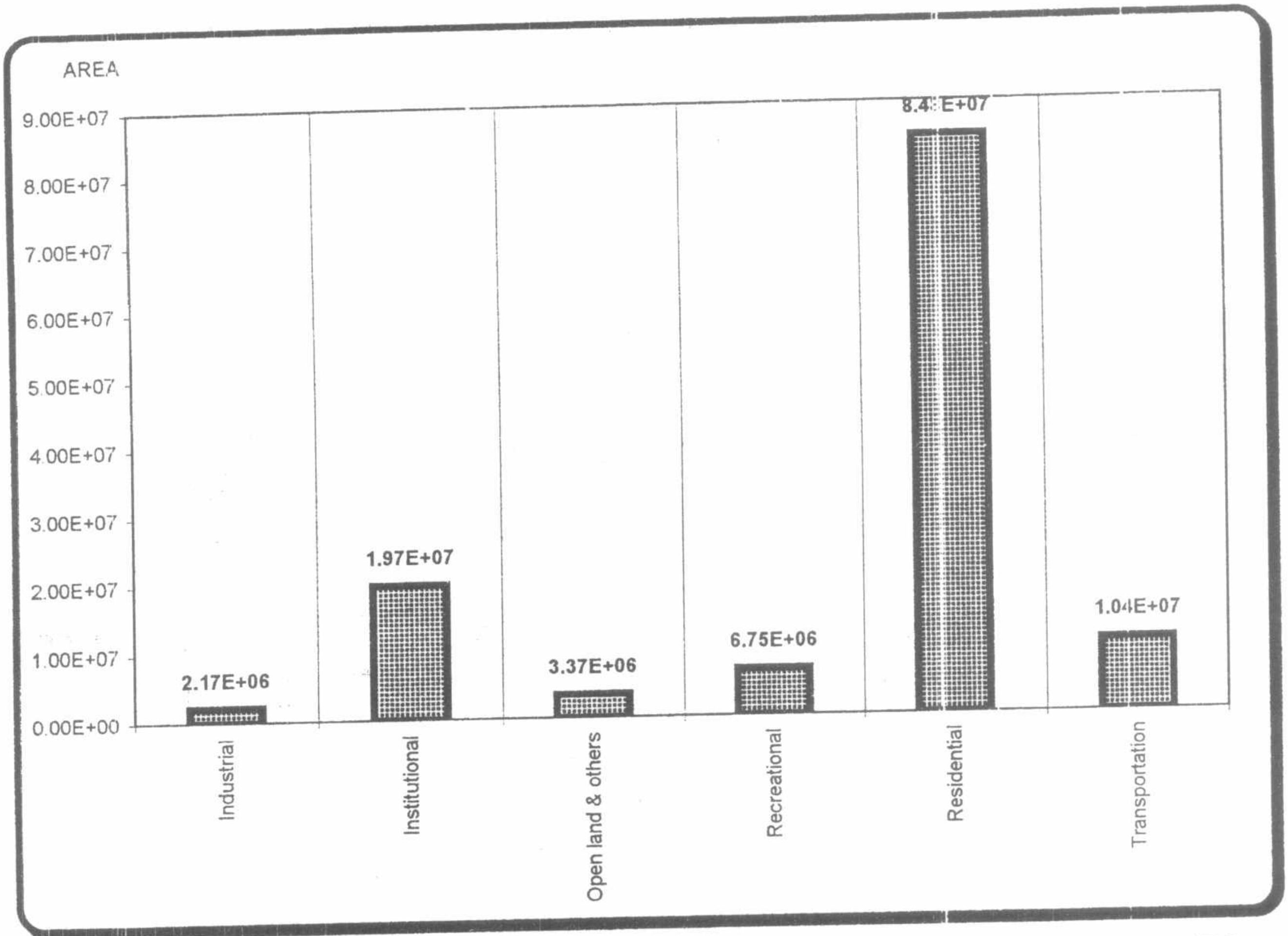
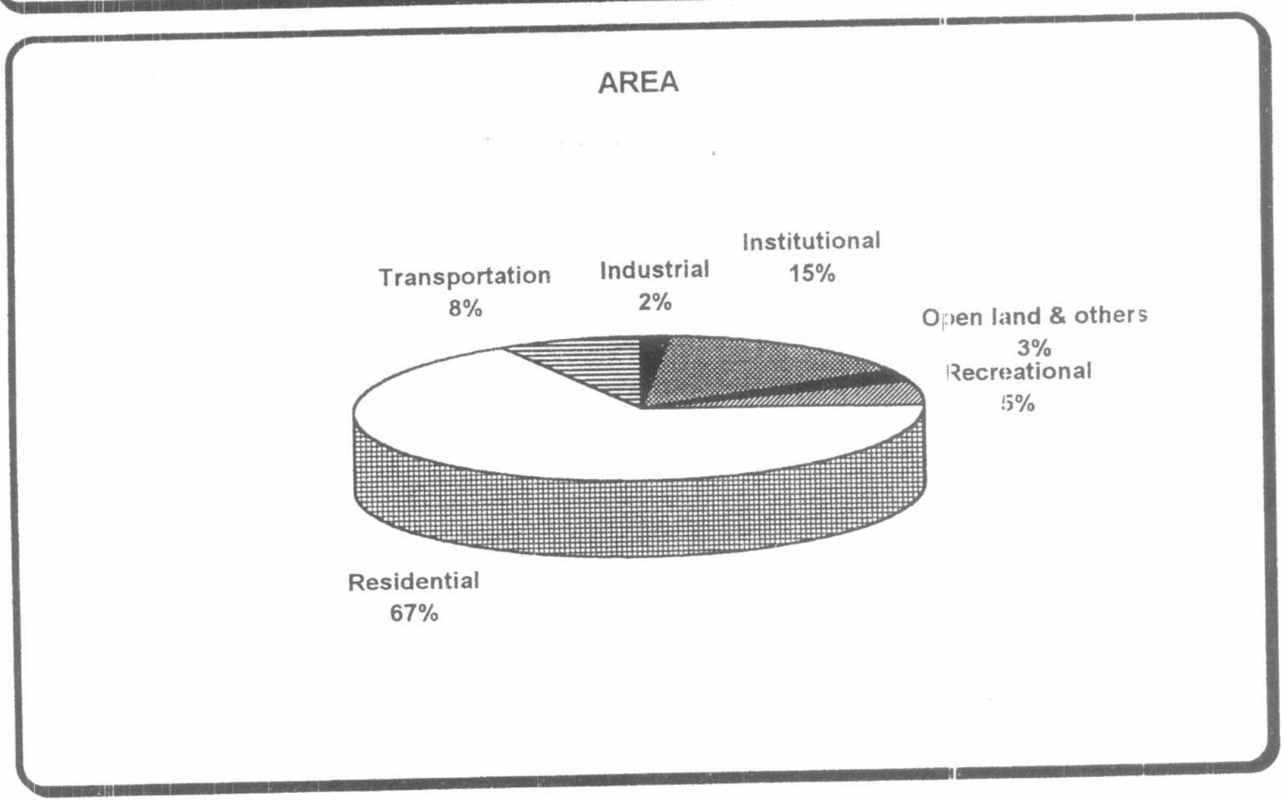


Fig.4. Main urban classes





Level2	Industrial	Institutional	Open land & others	Recreational	Residential	Transportation
AREA	2.17E+06	1.97E+07	3.37E+06	6.75E+06	8.48E+07	1.04E+07

Fig.5. Area of main urban classes

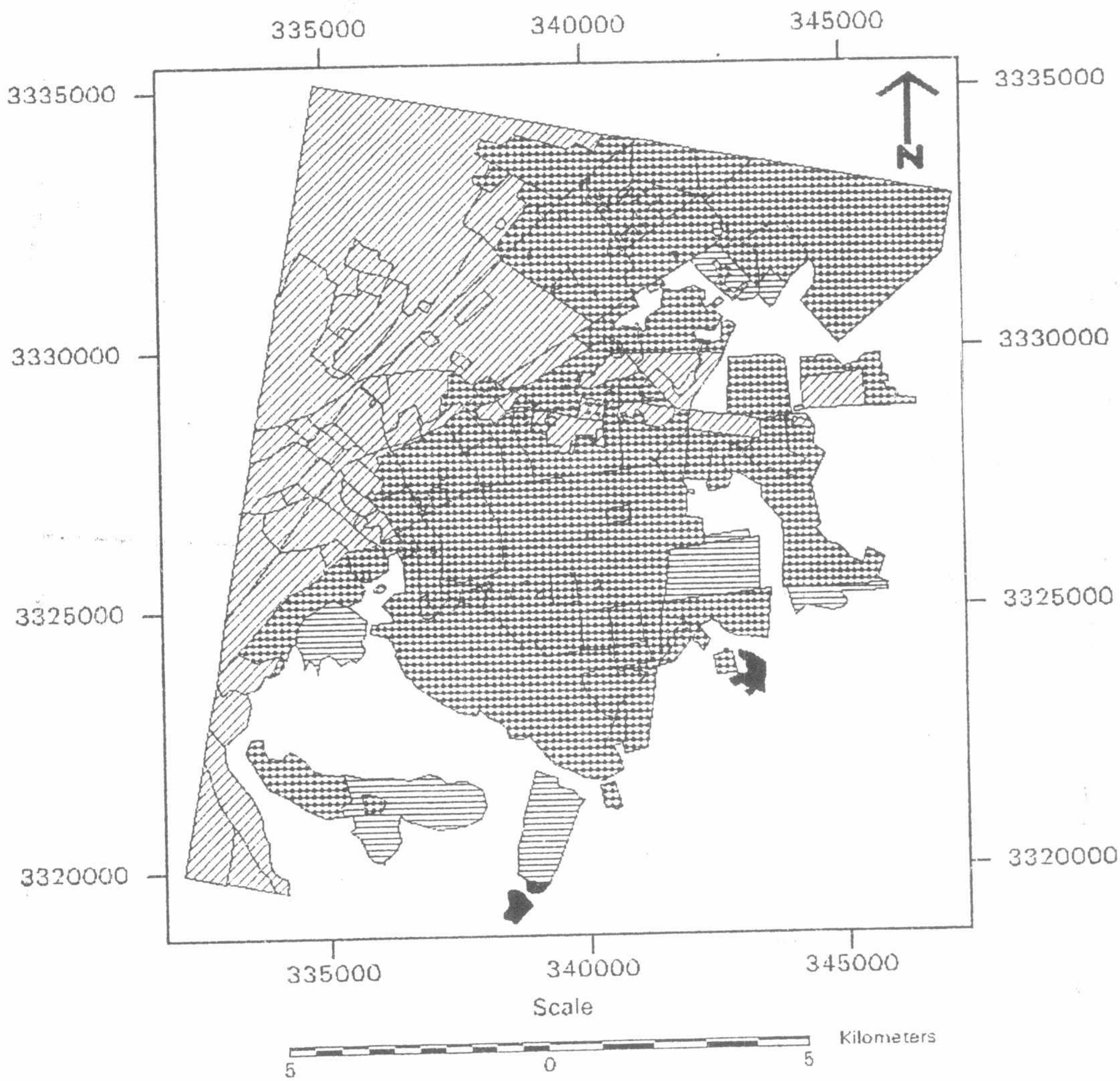
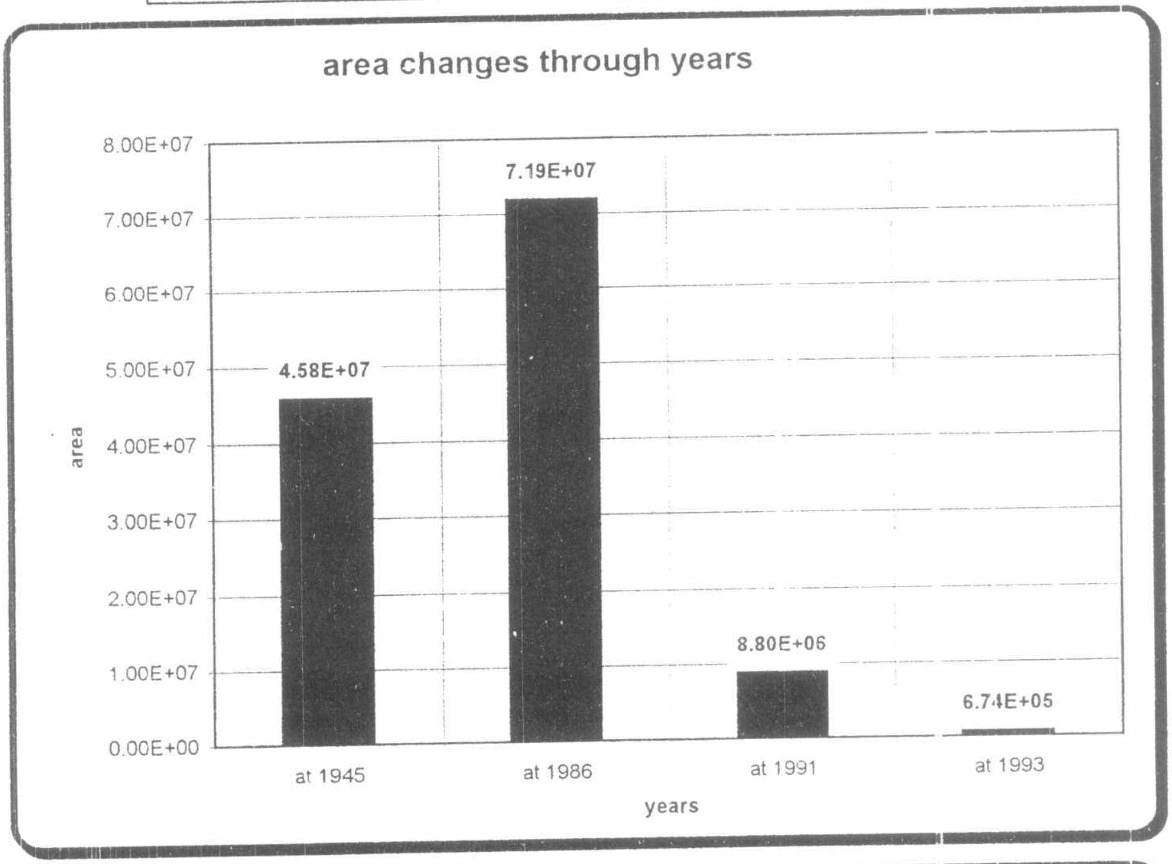


Fig.6. Urban changes in the study area

at 1945	at 1986	at 1991	at 1993	Grand Total
4.58E+07	7.19E+07	8.80E+06	6.74E+05	1.27E+08



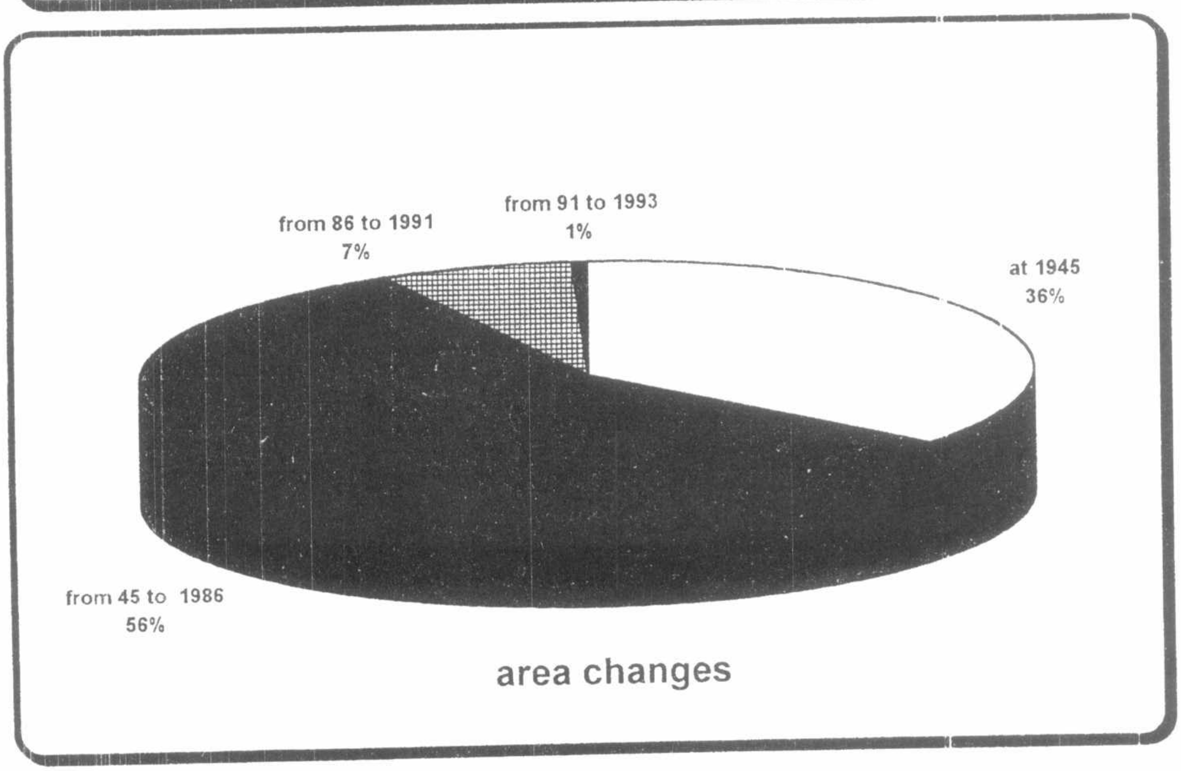


Fig.7. Urban area changes from 1945 to 1993